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Conservation assessment of five new records for the Orchidaceae of Colombia

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Abstract. Following the IUCN criteria, we assess the risk of extinction for five orchid species recorded for the first time from Colombia: *Acianthera viridis* (Luer & Hirtz) Luer, *Dichaea lankesteri* Ames, *Epidendrum lavendulum* Hágsater, *Masdevallia ariasii* Luer, and *Stenia stenioides* (Garay) Dodson & R.Escobar. We propose a preliminary global Red List categories of Endangered, Least Concern, Endangered, Vulnerable, and Least Concern, respectively, for these species. The main threats of these orchids are habitat degradation, small and degraded AOO and EOO, and a small number of known populations. The Caraño river basin, where these species occur in Colombia, is an important site for orchid conservation. Consequently, strategies are needed to ensure its preservation.

Key words: Andes, Caquetá, Caraño, cloud forest, orchids

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INTRODUCTION

Colombia harbors high Orchidaceae biodiversity, with more than 4700 species, with 65% of these from the Andes (Betancur et al. 2015). In the department of Caquetá, which is located between the Andes and the Amazonia, over 400 orchid species have been recorded, nearly half of them in Florencia (Arias et al. 2023). But most of the Andean-Amazonian foothill forests remain unexplored, and orchid species are still being reported for the first time from the country (Perdomo et al. 2020a, 2020b; Rincón-González et al. 2020; Arias et al. 2023; Rodríguez-S. et al. 2023; Rojas et al. 2023; Cuellar et al. 2024). The conservation status of orchid species needs to be assessed following the International Union for Conservation of Nature (IUCN) categories and criteria (IUCN 2012) and the guidelines for their use (IUCN 2022); Red List assessments are needed to establish priorities and policies for conservation.

The IUCN Red List of threatened species provides an objective, repeatable, and scientifically sound assessment of the risk of extinction for species under current circumstances (Miller et al. 2007; IUCN 2012). It is also the most important database of species at risk of extinction, and its methodology is now widely adopted and used by conservation biologists, as it provides an easy to understand and apply language (Omar and Elgamal 2021; Wagensommer et al. 2021; Zizka et al. 2021). Five criteria have been established by the IUCN that allow for aspects of a taxon to be assessed as threatened (IUCN 2012).

The B criterion evaluates the risk of extinction by considering the geographic range of the taxon, in combination with the number of populations and the quality of the habitat. Extent of Occurrence (EOO) uses a minimum convex polygon and the Area of Occupancy (AOO), uses a 2 km^2 grid that includes each occurrence to describe geographic range (IUCN 2012).

The B criterion is a valuable tool for identifying species at risk of extinction (Le Breton et al. 2019) and has been used to assess the conservation status of Orchidaceae (Leopardi et al. 2012; Millner et al. 2020; Perdomo et al. 2020a; Rodríguez-S. et al. 2023) and many other plant families. The known occurrences of the taxon are required to use B criterion and can be obtained from fieldwork, online databases, and herbaria. In the case of the decline, fragmentation, and fluctuations of the habitat, AOO and EOO can be estimated based on ongoing deforestation or can be calculated from deforestation data available on the web, a helpful approach for plant species. For epiphytic Orchidaceae dependent on phorophytes, the deforested areas represent the degradation and loss of their habitat and can be calculated and used to support the categorization.

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In this contribution we report five epiphytic orchid species for the first time from Colombia and use information of forest-cover loss to assess their conservation status and support their assignment into the threatened categories according to the B criterion of the IUCN.

METHODS

We carried out multiple botanical expeditions on the Caraño river basin, which is located in the eastern slopes of the Andes, Department of Caquetá, Colombia (Figure 1). We collected samples from the orchid species for herbarium vouchers, photographed living plants, and recorded geographic coordinates. We used taxonomic keys and species descriptions (Luer 1985, 1996; Pupulin 2007a, 2007b; Hágsater 2020) to identify the orchid species, and their identity was confirmed by the specialist in each group. Vouchers were deposited at Herbario Luis Sigifredo Espinal Tascón (CUVC); the herbarium acronym follows Thiers (2024).

To verify the known occurrences outside Colombia and confirm the new records for the country, we retrieved records and locations for each species from the web: Global Biodiversity Information Facility GBIF (https://www.gbif.org), Tropicos (Tropicos.org 2023), and SpeciesLink (https://specieslink.net); the Catálogo de Plantas y Líquenes de Colombia (http://catalogoplantasdecolombia.unal.edu.co/es/), and Herbario Amazónico Colombiano Dairon Cárdenas López (COAH; https://www.sinchi.org.co/coah), published information recovered from Google Scholar, and the Plan for the Study and Conservation of Orchids in Colombia (Betancur et al. 2015).

We used criterion B of the IUCN categories and criteria version 3.1 (IUCN 2012) to assess the risk of extinction for each species. First, we employed the package "*ConR*" (Dauby et al. 2017) in RStudio (RStudio Team 2021) to calculate the AOO and the EOO for each species using all known occurrences obtained from the web and our newly generated records. Second, we used the packages "*raster*" (Hijmans 2021), "*sf*" (Pebesma 2018), "*dplyr*" (Wickham et al. 2021) "*rgeos*" (Bivand et al. 2020), and "*tibble*" (Müller and Wickham 2021) to calculate the area of the EOO for Colombia (Figure 1). Third, we used the Global Forest Change dataset (Hansen et al. 2013) to calculate the deforestation from 2001 to 2022 in the EOO and the AOO for each species and used it as a proxy for habitat conservation. Additionally, we calculated deforestation in the Caraño river basin and habitat of the species in Colombia to evaluate its degradation.

Threatened categories for the five species are preliminary assigned based on the EOO (sub-criteria B1) and AOO (sub criteria B2), using the number of recorded locations and habitat fragmentation (qualifier a), and the forest cover loss in the AOO and EOO (qualifier b).

RESULTS

We recorded for the first time from Colombia five orchid species: *Acianthera viridis* (Luer & Hirtz) Luer (Figure 2A), *Dichaea lankesteri* Ames (Figure 2B), *Epidendrum lavendulum* Hágsater (Figure 2C), *Masdevallia ariasii* Luer (Figure 2D), and *Stenia stenioides* (Garay) Dodson & R. Escobar (Figure 2E).

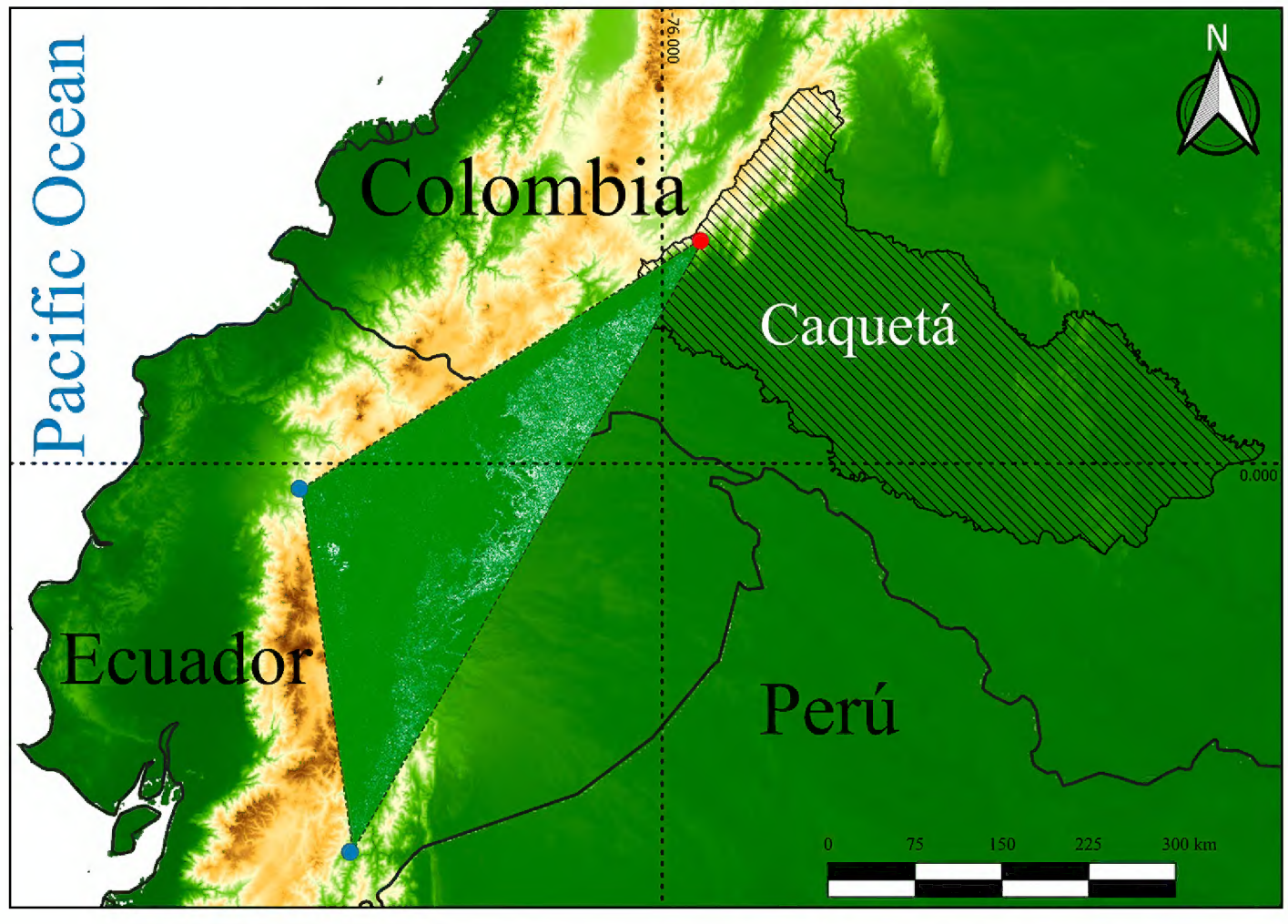

Figure 1. Extent of Occurrence (EOO; greentriangle) of *Acianthera viridis*, estimated from the records in Ecuador (blue points) and the new record from Colombia (red point), showing forest cover loss from 2001 to 2022 (white areas within the EOO).

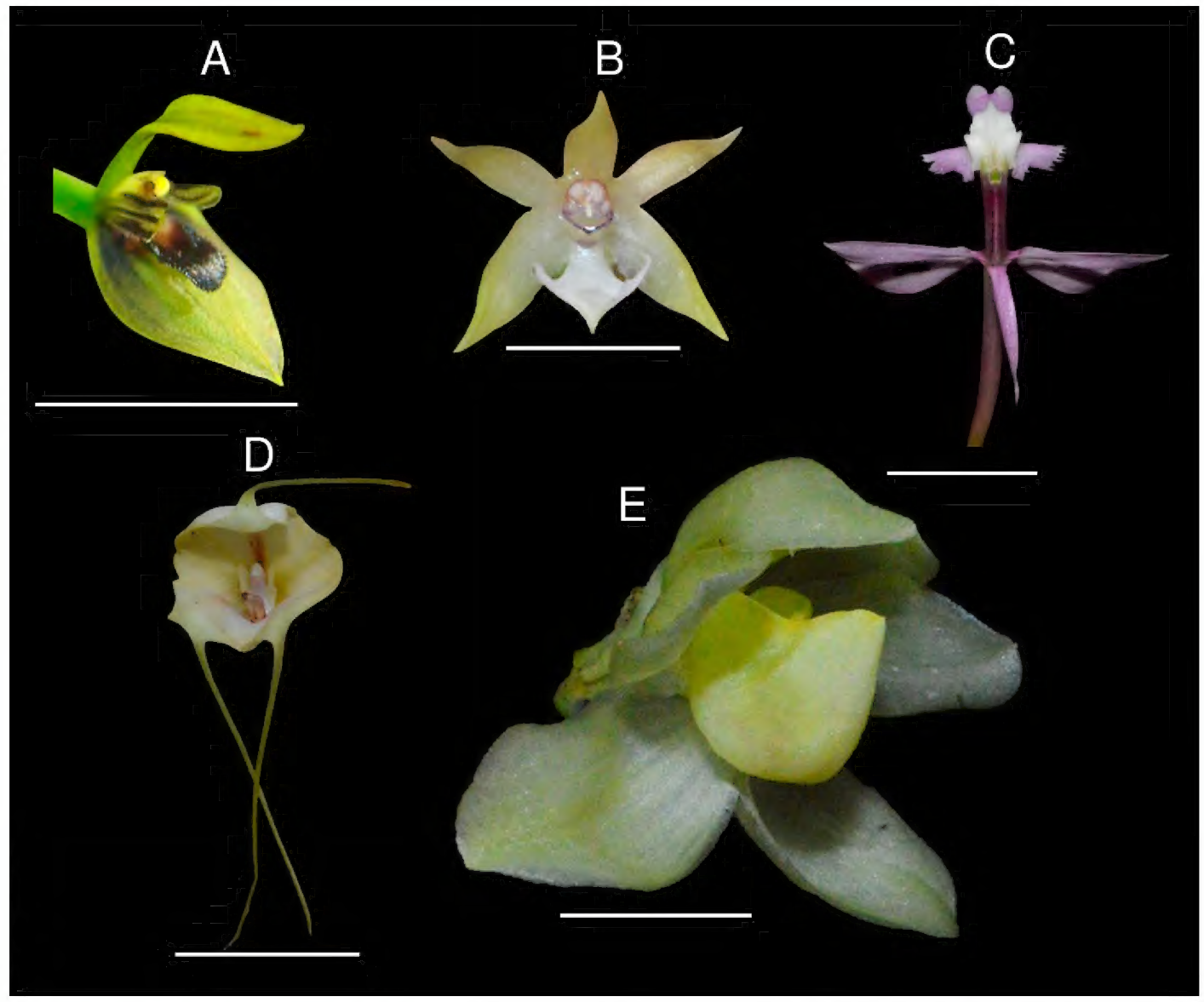

Figure 2. Flowers of five orchid species newly recorded from the Caraño river basin, Florencia, Caquetá, Colombia. **A.** *Acianthera viridis*. **B.** *Dichaea lankesteri*. **C.** *Epidendrum lavendulum*. **D.** *Masdevallia ariasii*. **E.** *Stenia stenioides*. Scale bars = 1 cm.

***Acianthera viridis* (Luer & Hirtz) Luer**, Lindleyana 11(3): 194–195. 1996.
Figure 2A

Known record. ECUADOR – Morona-Santiago • 1000 m elev. 20.I.1989; C. Luer et al.; MO4173.

New record. COLOMBIA – Caquetá • Municipio de Florencia, vereda El Caraño, cuenca hidrográfica del Río Caraño, camino Real; 01°44′14″N, 075°40′35″W; 1330 m elev.; 15.IV.2021; O. Perdomo et al. leg.; CUVC77338.

Global distribution. This species was previously known only from Ecuador. One record from Colombia was found in GBIF, but the identification is incorrect. In addition, this species was not cited in the catalogue of Plurothallidinae of Colombia (Karremans et al. 2023). The population we found in Colombia is 605 km to the north and 408 km to the northwest of the known populations in the eastern and western slopes of the Ecuadorian Andes (Figure 1).

Conservation status. Although this species is known from only one population in Colombia, it is also known from another country, and we expect the existence of more populations within the EOO. We propose Endangered globally under criteria B2ab(ii,iii) for *A. viridis* based on the few known populations (two in Ecuador and one in Colombia), the small EOO (58,832 km^2), ongoing deforestation within the AOO (6% of forest-cover loss), and the loss of 9.14% of EOO forest cover in the last two decades. For Colombia, we propose Critically Endangered under criteria B2ab(ii,iii), supported by the single population known, with only four individuals detected during our expeditions, the small and degraded AOO, and the deforestation of 23.4% of the EOO from 2001 to 2022 (Table 1, Figure 4B).

Description. Epiphytic, caespitose, up to 20 cm in size, green ramicauls, up to 10, slender and erects, 15 cm long × 0.25 cm in diameter, enclosed by a tubular bract in the lower fourth, plus 1 or 2 at the base, leaf blade 12 × 5.2 cm, elliptical-ovate, cordate at the base. Inflorescence 4.5 cm long, subcongested, arising through a spathe at the base of the leaf, oblique floral bract. Flower 1.5 cm, ovary 0.5 × 0.15 cm in diameter, dorsal sepal 0.9 × 0.2 cm pale green with 3 longitudinal dark purple lines at the base, lateral sepals fused 0.5 × 0.7 cm pale green with dark purple at the base, petals 0.3 × 0.15 cm pale green with 3 longitudinal brownish lines and serrate margin, labellum 0.4 × 0.2 cm with serrate margin, column 0.3 × 0.1 cm pale green.

Identification. *Acianthera viridis* is similar to *Acianthera ciliata* (Knowles & Westc.) F.Barros & L.R.S.Guim. from which it differs by the inflorescence which are shorter than the leaf (vs. longer than the leaf), pale green sepals (vs. yellow-orange), pale green synsepal with dark purple at the base (vs. yellow with red-brown below the middle), and dark purple lip (vs. red brown).

Table 1. Extent of Occurrence (EOO) and Area of Occupancy (AOO), both in Colombia and globally, along with deforestation, and IUCN Red List categories for the five orchid species reported for the first time from Colombia.

	Acianthera viridis	***Dichaea lankesteri***	***Epidendrum lavendulum***	***Masdevallia ariasii***	***Stenia stenioides***
EOO (km^2)	58832	93219.71	6478	97737.0	—
EOO deforested (km^2)	5375.54	6530.33	1231.38	4490.94	—
EOO deforested (%)	9.14	7.04	19.01	4.59	—
AOO (km^2)	12	68	16	12	8
Colombian EOO (km^2)	12194	4036	2260	5566.7	70
Colombian EOO deforested (km^2)	2853.54	17429	65212	1169.3	1.88
Colombian EOO deforested (%)	23.40	4.31	28.86	21.0	2.69
Colombian AOO (km^2)	4	4	4	4	4
Global IUCN criteria	B2ab(ii,iii)	—	B2ab(ii,iii)	B2ab(ii,iii)	—
Global Red List category	EN	LC	EN	VU	LC
Colombian IUCN criteria	B2ab(ii,iii)	B2ab(ii,iii)	B2ab(ii,iii)	B1+2ab(ii,iii)	—
Colombian Red List category	CR	CR	EN	EN	LC

***Dichaea lankesteri* Ames**, Schedulae Orchidianae 4: 56–57. 1923.
Figure 2B

Known record. COSTA RICA – San José • Cascajal, C. H. Lankester; AMES 24096.

New record. COLOMBIA – Caquetá • Municipio de Florencia, finca Las Brisas vereda El Caraño, Cuenca hidrográfica del Río Caraño; 01°44′14″N, 075°40′35″W; 1100 m elev.; 15.IV.2020; O. Perdomo et al. leg.; CUVC 77339.

Global distribution. Previously known from Costa Rica, Belize, and Panamá (Pupulin 2007b), this is the first record of the species from South America, 1055 km to the south-east of the Panamanian population (Figure 3A).

Conservation status. We propose Least Concern for *D. lankesteri* at globally because the EOO is large (93219 km^2) across four countries. Where occurrences are known, only 7.0% of the EOO has been deforested from 2001 to 2022, 21 populations have been recorded to date, and the AOO is 68 km^2. For Colombia we propose Critically Endangered, B2ab(ii,iii). In Colombia, there is only a single known population, the AOO has lost 1.5% of its forest cover since 2001, and the EOO (4036 km^2) has lost 4.31% of its forest in the same period (Table 1, Figure 4B), in addition to the ongoing deforestation in the Caraño river basin, where this species inhabits.

Description. Epiphytic, caespitose, horizontal to arching-pendent, densely clumped, ramicauls up to 17 cm, complanate, enclosed by the leaf base. Leaves green, distichous, decurved, linear, leaf blade up to 2 × 0.3 cm. Flower solitary, axillary, shortly pedicellate, dorsal sepal 0.9 × 0.4 cm, lateral sepals 0.8 × 0.3 cm, petals 0.7 × 0.2 cm, labellum 0.6 × 0.5 cm. white, 3-lobed, lateral lobes linear and sharp-curved, central lobe with apiculate apex, column 0.3 × 0.1 cm, ovary abbreviated, muricate.

Identification. *Dichaea lankesteri* is similar to *D. graminoides*, from which it differs by the long lateral lobes of the lip (vs. shorter). It is also morphologically similar to *D. glauca* differing by the short tip of the central lobe of the lip (vs. longer).

***Epidendrum lavendulum* Hágsater**, Icones Orchidacearum 17(2): 48–49. 2020.
Figure 2C

Type. ECUADOR – Napo • Cantón Archidona, Carretera Archidona-Baeza hacia Francisco de Orellana, Torre de Transmisión eléctrica en filo de la montaña; 1308 m elev., 2.XI.2017; Eric Hágsater & Marcos M. Jiménez León 15351; QCNE.

New record. COLOMBIA – Caquetá • Municipio de Florencia. finca Las Brisas, vereda El Caraño; 01°44′14″N, 075°40′35″W; 1117 m elev.; 20.III.2021; O. Perdomo et al. leg.; CUVC 77341.

Global distribution. This recently described species was considered endemic to the eastern slope of the Volcán Sumaco and foothills of the eastern Andes of Ecuador over 1300 m (Hágsater, 2020). We found a single population at 1117 m (asl), in the eastern slopes of the Colombian Andes, 334 km to the northeast of the Ecuadorean populations (Figure 3C).

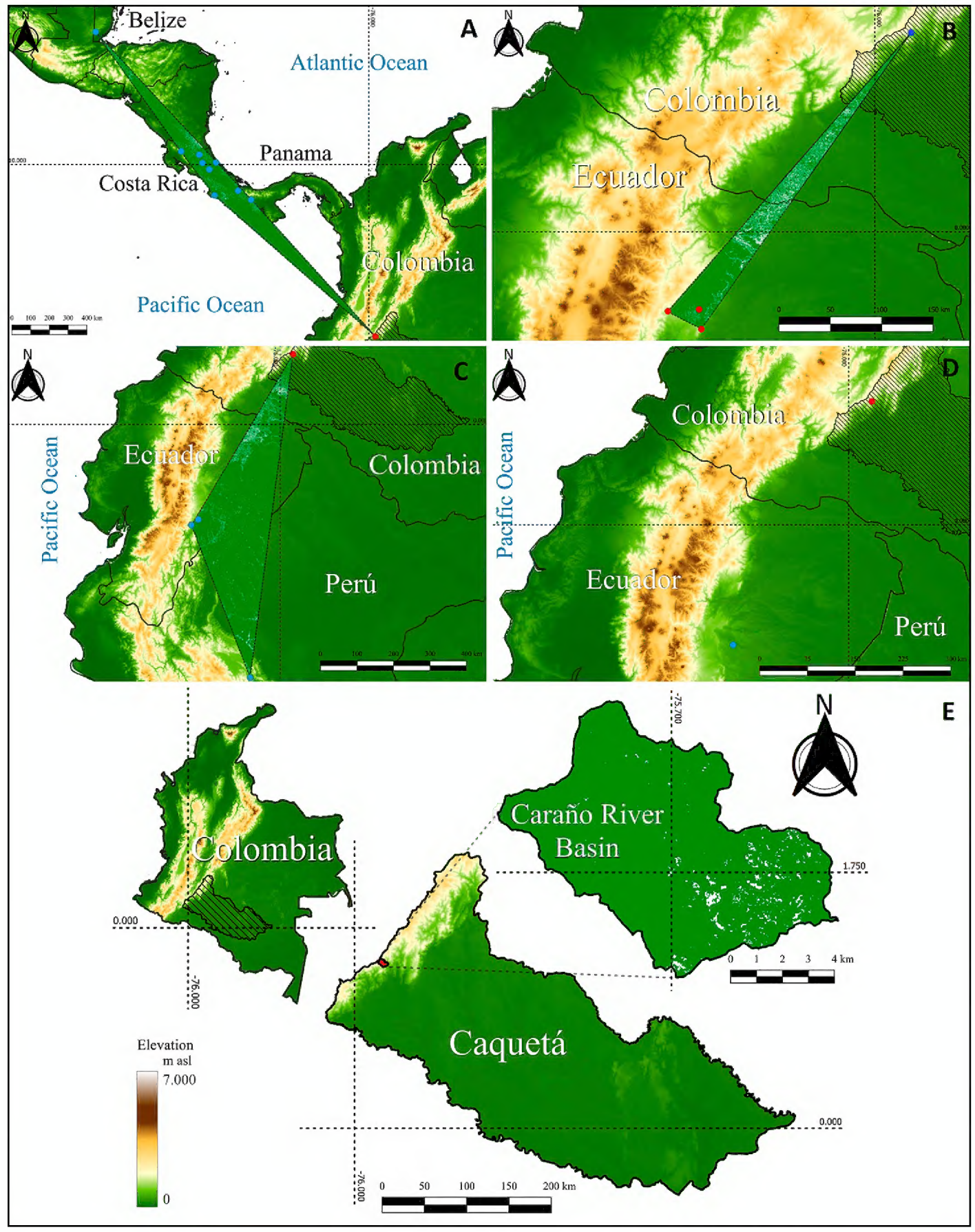

Figure 3. Distribution of known (blue points) and newly reported Colombian locations (red points), including the Extension of Occurrence (EOO; green triangle) and the areas of deforestation. **A.** *Dichaea lankesteri*. **B.** *Epidendrum lavendulum*. **C.** *Masdevallia ariasii*. **D.** *Stenia stenioides*. **E.** Location of the Caraño river basin and deforestation from 2001 to 2022 (white areas).

Conservation status. For *E. lavendulum* we propose that it is globally Endangered, B2ab(ii,iii) (Table 1) based on its small EOO (6,478 km^2), small number of populations (only four), a degraded AOO of 16 km^2, and 19% deforestation of the EOO in the last two decades. For Colombia, we assess the species as Critically Endangered because it is known from a single population with 15 individuals, forest cover in the AOO has undergone a 3.5% loss in the last two decades, the EOO is less than 5000 km^2 with more than 28% of the forest lost from 2001 to 2022 (Table 1, Figure 4C), and the continuous habitat degradation in the Caraño river basin. This species was previously categorized as Data Deficient in Ecuador (Hágsater 2020).

Description. Epiphytic, sympodial, caespitose, up to 1 m tall. Stems 27, cane like, 0.5 cm in diameter, compressed, covered by foliar sheats. Roots up to 3 mm in diameter, white, fleshy. Leaves green, distichous, coriaceous, up to 12 × 3 cm, lanceolate-oblong, apex rounded, margin entire. Inflorescence racemose, up to 35 cm long, peduncle 20 cm with bracts, rachis 15 cm long. Flowers 22, lilac, successive, open at time, non-resupinated, ovary up to 3.5 cm, sepals 1.2 × 0.4 cm, narrowly obovate, apex rounded, petals 1 × 0.3 cm, linear-lanceolate, margin entire. Lip 1.2 × 1 cm, 3-lobed, margin fimbriate, lateral lobes 0.4 × 0.5 cm, mid lobe 0.5 × 0.6 cm. Column 1 cm long with two wings.

Identification. *Epidendrum lavendulum* closest relative is *E. vinosum* Schltr., from which it differs by the laxly flowered inflorescence (vs. more compact inflorescence), lilac flowers (vs. salmon coloured), and mid-lobe of the lip flabelliform and fimbriate (vs. oblong and entire).

***Masdevallia ariasii* Luer**, Phytologia 57: 60. 1985
Figure 2C

Known record. PERÚ – San Martín • epiphytic in the forest between Tarapoto and Moyobamba; 1000 m elev., V.1982, M. Arias A-142, flowered in cultivation by W. & H. Koeniger in Muenchen, West Germany, 8.VIII.1984, C. Luer; MO 10397.

New record. COLOMBIA – Caquetá • Municipio de Florencia, vereda El Caraño, cuenca hidrográfica del Río Caraño, Camino Real, cerca al ramal para la finca de Don Miguel Trujillo; 01°44′14″N, 075°40′35″W; 923 m elev., 14.I.2021; O. Perdomo et al. leg.; CUVC 77342.

Global distribution. This species was previously known from Ecuador and Perú. The population we report here extends the distribution 520 km to the northeast of the Ecuadorean populations (Figure 3C).

Conservation status. We assess *M. ariasii* as Vulnerable under criteria B2ab(ii,iii) due to the only three populations reported to date, a small AOO (12 km^2) degraded by 9% deforestation, which also has affected 4.6% of the EOO (97737 km^2) in the last two decades. For Colombia, we propose Endangered due to the small EOO (5556 km^2), with only one known population, and an AOO of 4 km^2. Deforestation in the EOO in this country from 2001 to 2022 was 21%, and 2.7% in the river basin where we found the species, a notable habitat degradation for these epiphytic plants (Table 1, Figure 4D).

Description. Epiphytic, caespitose, 7 cm tall. Roots slender. Ramicaul 1 cm long, slender, erect, blackish. Leaves green, oblong rounded, erects, coriaceous, up to 4.0 × 3.0 cm. Single flowered, peduncle 4 cm long, suberect, slender, bract near the base. Floral bract tubular, pedicel 1 cm, ovary 0.8 cm, sepals pale yellow, microscopically pubescent internally, obovate, abruptly contracted into a slender, reflexed yellow-green tail of 2.2 cm long. Petals yellow-white, oblong, 0.4 × 0.15 cm, apex truncate-retuse. Lip cream, oblong-elliptical, 0.4 × 0.2 cm, with lateral wings and purple dots. Column 0.4 cm long, white. Capsule not seen.

Identification. *Masdevallia ariasii* is similar to *M. pteroglossa* Schltr., from which it differs by the oblong leaves (vs. elliptical), suborbicular flower and broader dorsal sepal (vs. narrow), and the lack of lateral wings in the lip.

***Stenia stenioides* (Garay) Dodson & R. Escobar**, Botanical Museum Leaflets, 26(1): 26–27. 1978.
Figure2E

Known record. ECUADOR – Pastaza • at confluence of Río Verde and Río Pastaza, Stacy s.n.; AMES.

New record. COLOMBIA – Caquetá • Municipio de Florencia, vereda El Caraño, cuenca hidrográfica del Río Caraño, Camino Real, cerca al ramal para la finca de Don Miguel Trujillo; 01°44′14″N, 075°40′35″W; 923 m elev., 18.XII.2020; O. Perdomo et al. leg.; CUVC 77344.

Global distribution. This species was only known from the type locality in Ecuador. The population we found in Colombia is 446 km to the northwest of that locality (Figure 3D). According to Pupulin (2007a), the illustrations of *S. stenioides* published by Dodson and Dodson (1984) and Bennet and Christenson (1994) depicting a plant from Zamora-Chinchipe do not correspond with the original description of *Chondrorhyncha stenioides* (Garay 1978). Consequently, this species is known only the type locality and the locality reported here.

Conservation status. We assessed the Red List category of *S. stenioides* using the known populations and the habitat quality of its AOO (4 km^2) where 3.9% of the forest cover has been lost in the last two decades. We could not calculate the EOO because the projection of the polygon requires at least three known points of occurrence. Although this species is known from only one population in Colombia and one in Ecuador, more populations in the Andean-Amazonian foothills of these countries are expected. The main threat for this species is deforestation of its habitat, which caused the loss of nearly 4% of the AOO since 2001. Thus, we propose that the species is globally of Least Concern. For Colombia, we also propose Least Concern; although there is a single population known to date, deforestation in the AOO and forest-cover loss in the Caraño river basin reached only 2.7% in the last two decades (Table 1, Figure 4E).

Description. Epiphytic, caespitose, 10 cm tall. Roots terete, thick, flexuous, born in the short rhizome. Stem abbreviated, enclosed by 5 imbricating sheaths. Leaves elliptic-lanceolate, distichous, 2.5 × 9.0 cm, conduplicate petiole to 2.5 cm long, yellow-green. Single flowered inflorescence, lateral, peduncle 1 cm long, ovary 1 × 0.3 cm, costate, glabrous; dorsal sepal 2.0 × 1.5 cm, yellowish cream, concave-cucullate, lateral sepals 2.3 × 0.9 cm, ovate-elliptic, same color, petals oblanceolate-obovate, 1.9 × 1.2 cm, lip indistinctly 3-lobed, strongly concave-saccate, subglobose, cordiform, 1.5 × 0.8 cm, lateral lobes subquadrates, midlobe triangular-ligulate, strongly concave, column 0.9 cm, cylindrical.

Identification. The closest morphological relative is *S. dodsoniana* Pupulin in sharing the deeply concave-cymbiform dorsal sepal, strongly reclinate over the column and the shape of the pollinarium, but

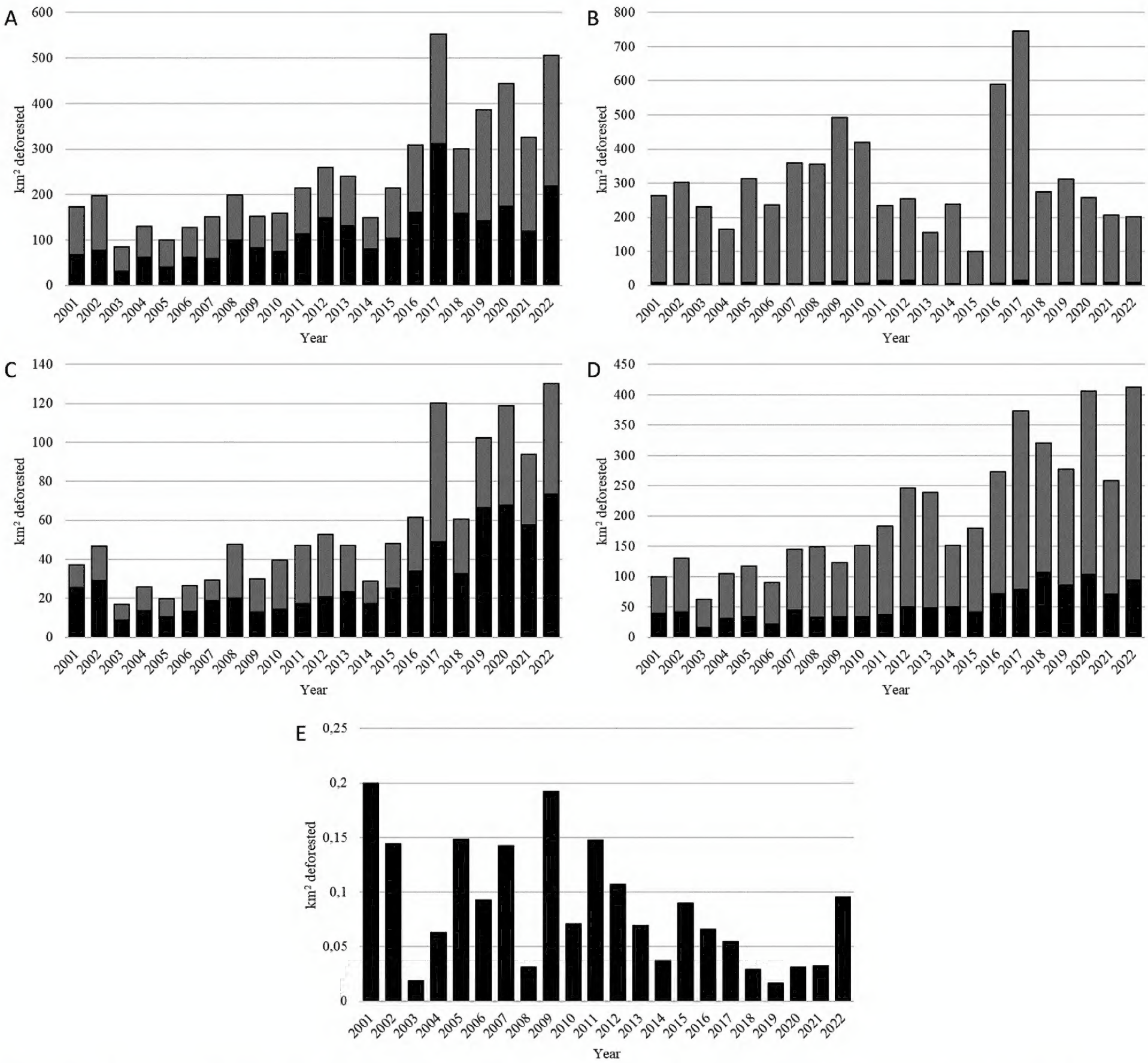

Figure 4. Yearly deforestation from 2001 to 2022 in the Extent of Occurrence (EOO) of the newly recorded orchid species and Caraño River watershed. **A.** *Acianthera viridis*. **B.** *Dichaea lankesteri*. **C.** *Epidendrum lavendulum*. **D.** *Masdevallia ariasii*. **E.** Caraño River watershed. In A–D, black bars represent deforestation in Colombia EOO, gray bars in the total EOO.

S. stenioides differs in the yellowish cream color of the perianth (vs whitish cream in *S. dodsoniana*), the ovate-elliptic lateral sepals (vs. elliptic), the cordiform lip (vs. subrectangular). Other species of *Stenia* that occur in Colombia are *S. pallida* Lindl. (Putumayo and Caquetá) with whitish yellow perianth (vs. yellowish cream in *S. stenioides*), and *S. uribei* P.Ortiz (Nariño) with a lip of different size and shape.

DISCUSSION

The five species we report here for the first time from Colombia increase the knowledge of the biodiversity in the Caraño river basin, the Caquetá department, and the Colombian Andes. Recently, *Myoxanthus xiphion* Luer, *E. porphyreonocturnum* Hágsater & R. Jiménez, and *Sievekingi hirtzii* Waldvogel were reported from this river basin, and six other species were reported from the Andean-Amazonian foothills of Colombia (Perdomo et al. 2020a, 2020b; Rincón-González et al. 2020; Rojas et al. 2023; Cuellar et al. 2024). All these records, including those presented here highlight the need for additional exploration and study of the plant diversity of this area and the importance of preserving the forest habitat. We draw the attention to the importance of this river basin and its unexplored forests for the conservation of orchids and the plant diversity of the Caquetá Department.

All the sites with information about deforestation and species occurrence help us improve the recovery of records, confirm the new occurrences, estimate the deforestation of AOO and EOO, and assess IUCN

Red List categories. Data from GBIF, SpeciesLink, and Tropicos has been previously used for this purpose, showing good results for the categorization of plant species using the B criterion (Ramirez-Villegas et al. 2012; Fernandes-Júnior et al. 2020; Lavor et al. 2020; Pérez-Sarabia et al. 2020; Robiansyah and Wardani 2020). For this paper we revised the digitized vouchers from the websites of the herbaria COL and COAH, a source of local information for Colombia and the Colombian Amazonia, respectively. The digitization of herbaria collections is an efficient tool that facilitates access to data, improves the development of new kinds of research in plant taxonomy, provides data for researchers and conservation policy makers (Soltis 2017; Vissers et al. 2017; Besnard et al. 2018), and contributes to the advancement of conservation assessments.

All the orchid species reported here are epiphytic, and consequently they dependent on the presence of phorophyte trees for development and recruitment. Therefore, the species and age composition of the forests is a important for their conservation, especially considering current changes in land use and climate (Köster et al. 2011; Rasmussen and Rasmussen 2018). Furthermore, orchids are highly vulnerable to deforestation and resulting changes in habitat quality and habitat fragmentation (Köster et al. 2009; Krömer et al. 2014; Alzate-Q et al. 2019). Thus, we used deforestation of the EOO, a significant threat for orchids, as an important measure in assessing the conservation status of each species (Gradstein and Acebey 2007; Teoh 2019) and support for the qualifiers of the B criterion. As a result, we obtained an adequate and robust categorization for the species assessed, using information available on the web and the IUCN categories and criteria (IUCN 2012, 2022).

To estimate the deforestation of the EOO for each country with occurrences, we used the raster maps from the Global Forest Change webpage, which is freely available on the web. It allows for a better comprehension of the conservation state of the EOO and AOO, and the categorization of the risk of extinction for the orchids we reported here, but it may be used for other epiphytic species. This dataset was successfully used for quantification of agricultural expansion into forests (Pendrill and Persson 2017), evaluation of the effects of forest cover loss on biodiversity in intact landscapes (Betts et al. 2017), identification of economically important forest types (Filewod and Kant 2021), and the study of the deforestation in Colombian protected areas (Clerici et al. 2020), which demonstrates this data set's value, accuracy, and utility in diverse research fields.

Using the B criterion allows us to employ the number of known populations and informationon deforestation to assess the five species studied here (Mace et al. 2008; IUCN 2022). Although use of criterion B has been criticized in some cases (Abeli et al. 2009; Brooks et al. 2019), when appropriately applied and supported by environmental and population information, the results can be useful to guide conservation strategies and policies (Collen et al. 2016; Tsiftsis et al. 2019; Barahona-Segovia et al. 2021).

We assessed the forest-cover loss of the Caraño river basin, where we found all five species reported here. Although 88% of this area is protected under Colombian environmental law, it has been continuously deforested, and the uncontrolled advance of the colonization frontier in this river basin and the construction of a road that crosses the basin may lead to the loss of the hydric productivity, the forests, biodiversity, and other environmental services provided by the river (Etter et al. 2006; Hoffmann et al. 2018; Bivand et al. 2020). The relatively large number of Critically Endangered orchid species in the Caraño river basin indicates this basin as a site of interest for the conservation of orchids in Colombia, with richness and rarity similar to municipalities like El Tambo (Cauca), San Francisco (Putumayo), and Charalá (Santander), which are areas of importance for the conservation of orchids (Alba-Patiño et al. 2021). Hence, the Caraño river basin needs additional government policies and strategies to protect its forest, enhance biodiversity knowledge, and generate economic alternatives for the farmers and other inhabitants based on the protection and rational use of the biodiversity, especially orchids.

We assessed each species using IUCN categories, subcriteria, and qualifiers, as shown in Table 1. We found that species met criteria in different threat categories; in such cases, we assigned the category that best reflected the conditions of the species and its habitat. Of the five species studied here, at the global level, two species were categorized as Least Concern, two as Endangered, and one as Vulnerable. In contrast, for Colombia we categorized two species as Critically Endangered, two as Endangered, and one as Least Concern because there is a single population known for each one, reduced area and deforestation of AOO and EOO, and the continuing decline in the forest cover of the Caraño river basin, which is the habitat for all these species.

At the global level, the AOO varies from 8 to 68 km^2, four species had an AOO equal to or less than 16 km^2. The smallest AOO was 8 km^2 for *S. stenioides*, which has only two records. The largest AOO was 68 km^2 for *D. lankesteri*, which has 21 populations known. The loss of forest cover from 2001 to 2022 in these species' EOO varies from 6478 km^2 for *E. lavendulum*, with only three populations known in two countries, to 93,219 km^2 for *D. lankesteri*, with 21 populations in four countries (Table 1).

In conclusion, the cloud forests of the Caraño river basin harbor a high diversity of Orchidaceae, and this basin can be considered important for the conservation of orchids. These forests need policies and strategies for the protection and preservation of these plants, based on the promotion of rational use and the development of local economy via ecotourism, research, and biocommerce, premises that applies for all the eastern slopes of the Andes and the adjacent Andean-Amazonian foothills. For the five orchid species we proposed the categorization, the major conservation threats are the loss of their habitat due

to deforestation, the few known populations, and the lack of local conservation strategies. The methodology we used here may be employed to assign the category of risk of extinction for any plant, based on the known occurrence localities and the deforestation in the EOO, obtaining adequate and robust categorizations.

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ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

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Author contributions

Conceptualization: OP, AZ, ETT. Data curation: AZ, ETT. Formal analysis: OP. Funding acquisition: ETT. Investigation: OP, AZ, ETT. Methodology: OP. Resources: OP, AZ, ETT. Supervision: AZ. Writing – original draft: OP. Writing – review and editing: OP, AZ, ETT.

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Data availability

All data that support the findings of this study are available in the main text.

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